MECHANISTIC EVALUATION OF ASPHALTIC PAVEMENT BASED ON BENKELMAN BEAM DEFLECTION

ROSNAWATI BINTI BUHARI

KOLEJ UNIVERSITI TEKNOLOGI TUN HUSSEIN ONN

KOLEJ UNIVERSITI TEKNOLOGI TUN HUSSEIN ONN

BORANG PENGESAHAN STATUS TESIS

JUDUL : MECHANISTIC EVALUATION OF ASPHALTIC PAVEMENT BASED ON BENKELMAN BEAM DEFLECTION

SESI PENGAJIAN : 2003/2004

Saya **ROSNAWATI BTE BUHARI**

(HURUF BESAR)

mengaku membenarkan tesis (PSM / Sarjana / Doktor Falsafah)* ini disimpan di Perpustakaan dengan syarat-syarat kegunaan seperti berikut:

1. Tesis adalah hakmilik Kolej Universiti Teknologi Tun Hussein Onn
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja
3. Perpustakaan dibenarkan membuat salinan tesis ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. ** Sila tandakan (√)

☐	SULIT	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)
☐	TERHAD	(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan .
√	TIDAK TERHAD	

Disahkan Oleh

(TANDATANGAN PENULIS)

(TANDATANGAN PENYELIA)

Alamat Tetap:
KG. PARIT BINGAN ,MK8,86400
PARIT RAJA, BATU PAHAT,
JOHOR

DR. KEMAS AHMAD ZAMHARI
Nama Penyelia

Tarikh: 10 APRIL 2004

Tarikh: 10 APRIL 2004

CATATAN:
* Potong yang tidak berkenaan
** Jika tesis ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan dikelaskan sebagai SULIT atau TERHAD
♦ Tesis dimaksudkan sebagai tesis bagi Ijazah Doktor Falsafah dan Sarjana secara penyelidikan atau disertai bagi pengajian secara kerja kursus dan penyelidikan atau Laporan Projek Sarjana Muda (PSM)

" I have read this proposal and it is my professional view that it fulfill the requirement of Masters Degree in Civil Engineering in KUiTTHO ".

Signature : .....

Name of Supervisor : DR. KEMAS AHMAD ZAMHARI

Date : 10 APRIL 2004

MECHANISTIC EVALUATION OF ASPHALTIC PAVEMENT BASED ON BENKELMAN BEAM DEFLECTION

ROSNAWATI BTE BUHARI

This Project Report is present to fulfill apart from award condition for Masters Degree of Civil Engineering .

Faculty Of Civil Engineering
Kolej Univesiti Teknologi Tun Hussein Onn

OCTOBER 2003

Especially To My Lovely

Father, Mother, Husband, Sister and Brother.....

" Thanks For Everything....."

ACKNOWLEDGEMENT

I am very grateful to those who have helped me in preparing this Thesis. Firstly I want to express my gratitude to Dr Kemas Ahmad Zamhari as a Supervisor, for his interest and simulating discussion and response during development of this project. I am also grateful for his helpful comments, suggestion and criticisms .

I am also thankful to the instructors in helping the preparation of the instruments and degree students for their assistance during field test. My sincere thanks also are extended to the Department of Civil Engineering of KUiTTHO for the systematic management and Jabatan Kerja Raya for the data given.

Finally , I am grateful with deep appreciation for the continued support, patience and encouragement of my husband and all my friends.

ABSTRACT

When empirical evaluation of pavement layers overlay was practiced, the selection of layer thickness and properties was made without benefit of mechanistic analysis. The application of elastic theory to the design of overlays on existing pavement requires that the modulus of elasticity be assigned to the existing structural system. Elastic moduli are determent from pavement surface deflection. Benkelman Beam conducted under WASHO method to collect data in order to find deflection condition of existing pavement. Based on present study, graphical method which deflection dependent was developed to determine parameters of elasticity. The objective of the present study are to find out the elastic/stiffness modulus parameters for the layer of asphaltic pavement by using Benkelman beam deflection and compare the remaining life of the existing pavement and to propose overlay thickness based on conventional and mechanistic analysis approach. As the conclusion, from the analysis I have determined that the elastic modulus can obtained by interpretation of Benkelman Beam deflection test also have proved that the mechanistic analysis is the available evaluation for existing pavement.

ABSTRAK

Kaedah penilaian empirical merupakan teknik untuk menentukan penindihan semula lapisan permukaan turapan yang dipraktik selama ini. Kaedah ini tidak menggunakan analisis mekanistik dalam pemilihan ketebalan lapisan. Merekabentuk lapisan penindihan semula dengan aplikasi keanjalan turapan memerlukan nilai elastic modulus struktur turapan asal. Nilai elastic modulus ditentukan daripada lenturan permukaan turapan. Ujian Benkelman Beam dijalankan dengan berpandukan kaedah WASHO bagi mendapatkan keadaan lenturan turapan yang asal. Nilai-nilai elastic modulus bagi setiap lapisan turapan diperolehi daripada graf yang telah dibangunkan dengan merujuk kepada nilai lenturan turapan yang telah dicerap serta bantuan persamaan –persamaan yang telah dinyatakan pada kajian-kajian terdahulu. Kajian ini adalah untuk mencapai objektif-objektif yang telah ditetapkan iaitu mendapatkan nilai elastic modulus bagi lapisan turapan *asphalt* dengan menggunakan nilai lenturan daripada ujian Benkelman Beam dan membuat perbandingan nilai jangka hayat turapan asal yang diperolehi dengan menggunakan kaedah konvensional dan mekanistik. Disamping itu kajian juga dijalankan untuk mencadangkan ketebalan lapisan yang sesuai untuk jangkahayat turapan dengan menggunakan kaedah konvensional dan analisis mekanistik. Kesimpulannya daripada hasil analisis yang telah dijalankan, nilai elastic modulus boleh diperolehi daripada ujian lenturan Benkelman beam dan analisis secara mekanistik merupakan kaedah yang lebih tepat untuk penilaian turapan sedia ada.

CONTENT

TABLE LIST

FIGURE LIST

SHORTFORM LIST

AASHTO	:	Association of State Highway and Transport Officials.
NDT	:	Non- Destructive Test
RRD	:	Representative Rebound Deflection
ESAL	:	Equivalent Standard Axle Load

LIST OF APPENDICES

CHAPTER I

INTRODUCTION

1.1 INTRODUCTION

In year of 1980s there has been increasing interest in the development of rational design procedures for highway pavement. For example the Association of State Highway and Transportation Officials (AASHTO) Guide for Design of Pavement Structure (1986), and AUSTROAD, though still based on the empirical concept which had previously experience been considered. Design the overlay to improve existing pavement has become the major activity of almost highway agencies as a result of increase awareness of the importance of maintaining the public infrastructure, together a relative of scarcity of fund for new construction.

Although, in recent years attention has turned to the used of fundamental analyses of pavement response to load, including the evaluation of pavement performance. This last method of pavement design evaluation is usually referred to as a mechanistic evaluation procedures. The best mechanistic evaluation procedure use, to find the pavement responses such as strain, stress and deflection at the critical point in the pavement structure. The pavement response then relate with the empirical condition on the field. Mechanistic evaluation procedure are perceived to have several advantage over methods based on judgment or strictly empirical relationships.

Field testing method such as non-destructive testing (NDT) can provide importance information of those pavement deflection property for the pavement

analyses. Around 1960-1970 Benkelman Beam is the most popular method for the deflection measurement then interpretation it using empirical method. Falling Weight deflection recently take over which is more simple.

1.2 PROBLEM STATEMENT

In empirical evaluation of overlay, the selection of layer thicknesses and properties was made without benefit of mechanistic analysis. So that the mechanistic evaluation method which considered layer elasticity need to improve the solution.

So that this study will focus on investigating of mechanistic variable such as elastic modulus to improve the evaluation method also the application of elastic theory to design of overlays on existing pavement by interpretation Benkelman Beam test data. Falling Weight Deflection is an accurate method to find deflection but it needs more investment compare Benkelman Beam. Benkelman Beam also use to find deflection but until nowadays the interpretation of deflection data finding still using empirical analysis.

1.3 RESEARCH OBJECTIVES

The objective of this study are:

1. To find out the elastic/stiffness modulus parameters based on surface deflection by using Benkelman beam test.

2. To compare remaining life at the existing pavement using conventional and mechanistic analysis using Benkelman Beam Deflection.
3. To compare propose overlay for further layer design

1.4 SCOPE OF THE PROJECT

The scope of the project are:

- This study is focused on Benkelman Beam method in order to find the deflection and mechanistic variable/parameter of existing pavement.
- Pavement structure : flexible pavement with specific to linear elastic
- The parameter used are temperature, traffic volume and pavement structure.

1.5 EXPECTED RESULTS

1. Elastic modulus parameters
2. Comparison remaining life at the existing pavement using conventional and mechanistic analysis using Benkelman Beam Deflection.
3. Propose overlay for further layer design life.

1.6 PERFORMANCE PLAN

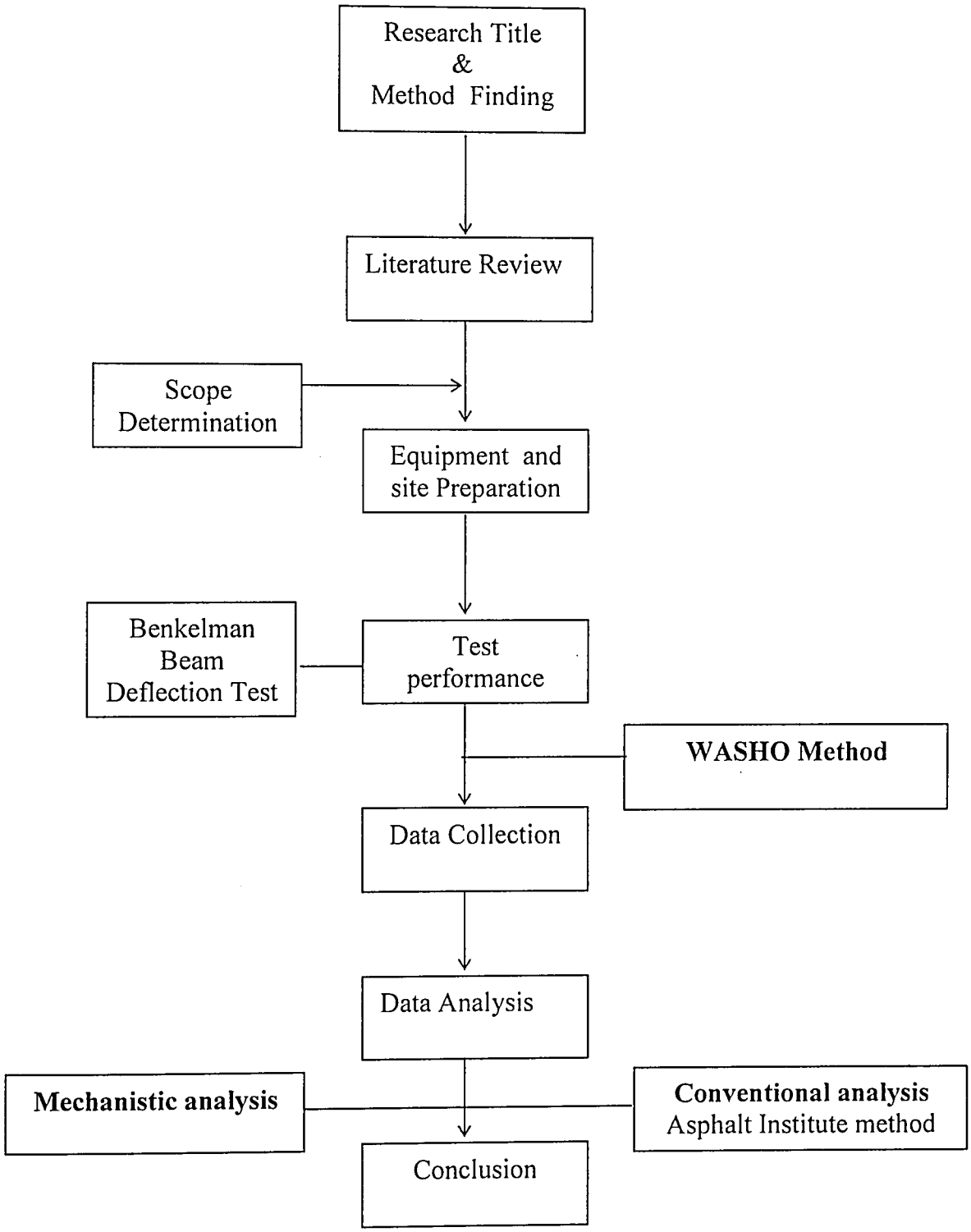

Figure 1.1: Methodology Of The Study

CHAPTER II

LITERATURE REVIEW

2.1 PAVEMENT STRUCTURE

Flexible pavement structure consists of the surface course and the underlying base and subbase courses. Each layer received the load from the above layer, spread the out the passes on these loads to the next layer.

Surface course is the top layer and the layer that comes in contact with traffic. It may be composed of one or several different sublayer. Base course plays a prominent role in the support and dispersion of the traffic loads and surface course forms an impermeable and flexible lining of high elastic modulus. Subbase course is the layers of the specified material build up to the required designed thickness immediately over laying the subgrade. It serve as an aid to disperse the load from the base course before transmitting it to the subgrade. Subgrade is the upper most part of the soil, natural or imported, supporting the load transmitted from the overlaying layers.

2.2 BENKELMAN BEAM

The Benkelman Beam Test is one of the Non Destructive Field Test, which is able to record the pavement surface deflection occurring under actual truck traffic loading at different discrete points along the pavement. The results of these measurements can be used for analyzing the bearing capacity of an existing pavement structure and to design the possibly required overlay.

Figure 2.1 shows the beam developed by A. C. Benkelman in connection with the WASHO Road Test. Mr. Benkelman devised the scheme whereby deflection at the pavement surface is measured by means of a long beam; the deflections are recorded by means of a dial placed at one end of the beam. The Benkelman Beam is used with a loaded truck –typically 80kN (18000 Ib) on a single axle with dual tyre inflated to 480 to 550 kPa (70-80 psi) .

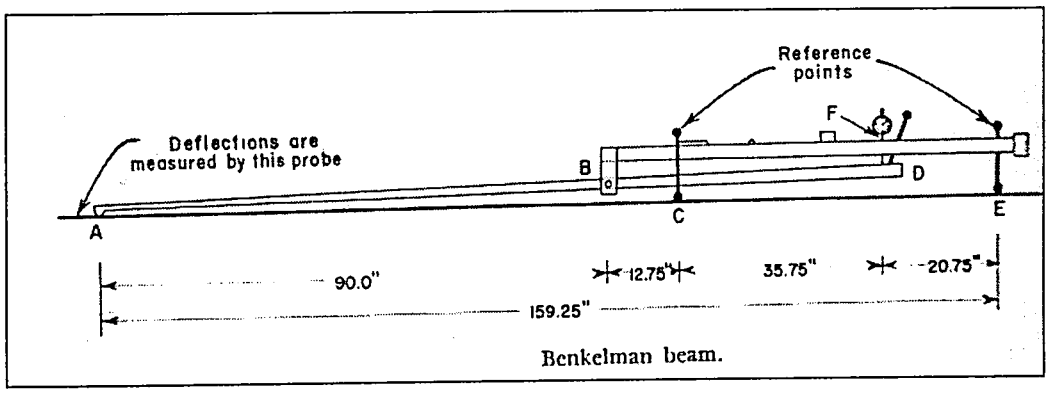

Figure 2.1 : Benkelman Beam Deflection Test

In Figure 2.1 the deflection at point A is measured by means of the deflection dial at point F. The deflections are measured relative to the reference points at C and E. The Benkelman beam principle has been mechanized so that a large number of readings can be obtained by continuous reading of deflection under a loaded axle.

The Benkelman Beam is low cost but is so slow, labor intensive and does not provide a deflection basin.

2.3 Pavement type and Wheel Load

2.3.1 Type Of Pavement

The flexible pavement may consist of a relatively thin wearing surface built over a base course and subbase course, and they rest upon the compacted subgrade. In contrast, rigid pavements are made up of Portland cement concrete and may or may not have a base course between the pavement and subgrade.

The essential difference between the two types of pavements, is the manner in which they distribute the load over the subgrade. The rigid pavement, because of its rigidity and high modulus of elasticity, tends to distribute the load over a relatively wide area of soil; thus, a major portion of the structural capacity is supplied by the slab itself. The major factor considered in the design of rigid pavements is the structural strength of the concrete. For this reason, minor variations in subgrade strength have little influence upon the structural capacity of the pavement.

It should be noted at this point that the classical definition of flexible pavements includes primarily those pavements that have an asphalt concrete surface. The load carrying capacity of a truly flexible pavement is brought about by the load-distributing characteristics of the layered system. Flexible pavements consist of a series of layers

with the highest-quality materials at or near the surface. Hence, the strength of a flexible pavement is the result of building up thick layers and, thereby, distributing the load over the subgrade, rather than by the bending action of the slab. The thickness design of the pavement is influenced by the strength of the subgrade. If an asphalt pavement has high stiffness, it may behave essentially as a rigid pavement and fatigue of the surface or of any pavement component may become critical.

2.3.2 Tire Pressures, Contact Pressure and Tire Imprint

If the effect of the tyre wall is ignored, the contact pressure between the tyre and pavement must be equal to the tyre pressure. For low-pressure tyres, however, contact pressures under the tyre wall may be greater than at the center of the tyre. For high-pressure tyres the reverse is true. For most problems, however, the assumption is made that contact pressures are uniform over the imprint area.

In the majority of the problems, circular tyre imprint are assumed. Hence the standard wheel loading as two circular vertical load (total) load 40kN uniform vertical stress distribution in the range of 550-700 kPa center to center spacing of the load 330 mm and radius of each load $R=\sqrt{(L/\pi\rho)}$ where L = load on one tire of the axle and ρ is tire pressure.